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MAINTENANCE MANUAL FOR TEST DEMODULATOR CD-3801

October 1969

INFORMATION & ELECTRONIC SYSTEMS DIVISION

BROWN ENGINEERING

A TELEDYNE COMPANY

Research Park • Huntsville, Alabama 35807

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The Magnavox Company
Fort Wayne, Indiana

MAINTENANCE MANUAL
FOR
TEST DEMODULATOR CD-3801

Brown Engineering, A Teledyne Company
Design Specification DS-3801
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Original Issue

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PREFACE

This manual includes the description, theory of operation, installation procedures, and maintenance procedure for the CD-3801 Test Demodulator. Schematic diagrams are not included in this manual, but will be published as separate items.

INTRODUCTION

SCOPE OF MANUAL:

This manual is intended to provide operating and maintenance personnel with sufficient technical information in sufficient detail to permit intelligent use of the Test Demodulator, CD-3801.

PURPOSE OF SYSTEM:

The Test Demodulator accepts the DIFAR composite signal output from the CD-3800 DIFAR System Simulator. Circuitry is included in the Test Demodulator to demodulate the NS and EW signals centered about the 15 kHz carrier; to separate the E_{OMNI}, E_{NS}, and E_{EW} signals; and to buffer the three resulting audio signals for measurement by commercial test equipment.

1.0 INSTALLATION:

The Test Demodulator will be installed under the direction of the Brown Engineering Company Resident Engineer. All questions pertaining to pre-installation assembly operations, installation, and checkout should be directed to the Resident Engineer.

2.0 DESCRIPTION:

2.1 PHYSICAL:

Panel space of 10 1/2" high by 19" wide is required for the Test Demodulator chassis. The panel is mounted on chassis slides which permit the unit to be withdrawn from the Calibration Station sufficiently to permit the removal and use of an extender card for any card or subassembly in the chassis. The chassis slides also permit the unit to be tilted or removed from the Calibration Station. Connection to the panel is made through receptacles located on both front and rear panels.

2.2 MECHANICAL:

The Test Demodulator is designed to operate when mounted in an Amco FJA-52-19-25 cabinet (Calibration Station), or when removed from the cabinet, it operates as a self-contained unit.

Human engineering was used in designing the front panel to facilitate maximum operational effectiveness. The panel is secured in the equipment rack with captive screws, and is equipped with straight handles on both sides for use in lifting and carrying.

The Test Demodulator front panel is painted with Hanna Machinery Grey (XB 3928) enamel and panel markings are engraved and filled with white paint.

2.3 ELECTRICAL:

The Test Demodulator was designed to accept and demodulate a composite signal from the CD-3800 DIFAR System Simulator.

The composite signal is applied to a pair of balanced demodulators. The reference signal is derived from the composite by filtering

out the 7.5 kHz pilot tone. An indicator lamp shows when the reference is in the same quadrant as the pilot, and a meter displays the actual phase difference. The NS output signal comes from one demodulator, the EW output comes from the other, and the OMNI output comes from the composite signal after appropriate filtering. All three signals are brought to front panel receptacles to allow monitoring and display on commercial test equipment. In addition, these signals with additional filtering are routed to a rear panel receptacle to allow them to be connected directly to the rear input terminals of a Hewlett-Packard 3450A Multifunction Meter.

Built-in test equipment provides a convenient means of calibrating the phase null meter and of balancing the outputs from the two demodulators.

2.4 SPECIFICATIONS:

2.4.1 Physical:

The Test Demodulator is mounted on chassis slides which permit the removal of cards or subassemblies. The Test Demodulator is mounted on a metal chassis with standard 19-inch wide front panel. The chassis is suitable for mounting in Amco FJA 52-19-25 equipment cabinets, or equivalent.

2.4.2 Mechanical:

The Test Demodulator is mounted on a metal chassis with all steel parts cadmium plated and coated with a conductive finish. All aluminum parts are coated with a conductive finish. The Test Demodulator is designed so the panel may be removed from the equipment cabinet.

2.4.3 Electrical:

The Test Demodulator demultiplexes the NS, EW and OMNI signals from the DIFAR composite signal. EW and NS signals are extracted by two synchronous demodulators whose 15 kHz gate signals are adjusted to be in-phase and in quadrature with the 15 kHz Pilot component of the composite signal. The outputs of the demodulators are filtered and buffered to reduce the high frequency demodulation products, while maintaining phase integrity between channels. These signals appear at the EW and NS output jacks on the front panel and with additional filtering to further reduce the high frequency products appear at the output jack on the rear panel. The OMNI signal is extracted from the composite signal by filtering out the high frequency components of the composite retaining only the baseband OMNI signal.

The OMNI channel is designed to have the same phase characteristics as the directional channels; thus, phase integrity is maintained between the OMNI and directional signals.

The three signal channels are so designed and calibrated as to maintain phase integrity between any two channels within ± .3° at the front panel output jacks.

The output levels of the targets are a function of the level of the corresponding components of the composite input signal.

$$\frac{\text{NS OUT}}{\text{NS (one sideband)}} = \frac{\text{EW OUT}}{\text{EW (one sideband)}} \approx 3.5$$

$$\frac{\text{OMNI OUT}}{\text{OMNI IN}} \approx 4.1.$$

Output impedance is less than 1.0 ohm resistive.

2.4.4 Environmental:

The Test Demodulator is intended for use and storage only in sheltered areas wherein exposure to climatic and environmental

conditions is limited. The following environmental conditions shall apply:

a. Shock and Vibration: The Test Demodulator shall be designed to withstand shock and vibration loads of 3g acceleration normally encountered during shipment and handling.

b. Temperature: The Test Demodulator shall operate within specifications over the range of +65°F to +100°F ambient.

c. Humidity: The Test Demodulator shall operate within specifications when exposed to relative humidity up to 95 percent.

3.0 OPERATING INSTRUCTIONS:

Operation of the Test Demodulator panel is always in conjunction with a Magnavox Test Procedure. Therefore, the purpose of this section is only to acquaint the user with the function of each control and to explain how to set up the system for each operating mode.

3.1 CONTROLS:

All controls for the Test Demodulator panel are located on the front panel. Table 3-1 provides a list of the controls and functions performed.

The following section provides the procedures for operating the Test Demodulator panel. These instructions assume the panel has been properly installed and connected to the ac power source.

3.2 INITIAL SETUP:

Prior to operating the Test Demodulator panel, the chassis and signal grounds must be connected together. The Test Demodulator requires a thirty minute warmup period. During this thirty minutes, the panel controls can be set up for operation.

The Test Demodulator operates with two sets of output signals (NS, EW, and OMNI). The first set which has minimum filtering is available at connectors J1, J2, and J3 on the front panel. These outputs are intended to be used for phase measurements between signal channels. They are also suitable for amplitude measurement with a narrow band instrument such as a wave analyzer or tracking filter. The second set of signals, which is available at connector J7 on the rear panel, has had additional filtering and is suitable for broadband amplitude measurements. These outputs are not suitable for use in phase measurements.

TABLE 3-1

TEST DEMODULATOR
FRONT PANEL CONTROLS

Control Number	Title	Position	Function
F1	AC Power Fuse	---	Fuse ac power to Control Panel and Test Demodulator.
S1	AC Power Switch	ON OFF	Controls ac power to Test Demodulator and Control Panel.
DS1	AC Power Lamp	---	Illuminated - AC Power ON Extinguished - AC Power OFF.
S2	Input	DIFAR	Selects input signal selected by S4.
		BAL.	Selects internal calibration signal to balance output amplifier.
		METER CAL	Selects internal calibration signal to adjust meter amplifier.
S3	Phase Advance	---	Provides 90° incremental phase advance of 15 kHz reference.
S4	DIFAR Input	GRAM I GRAM II GRAM III GRAM IV EXT	Selects source of composite DIFAR signal.
S5	Meter Sensitivity	X1 X10 X100	Selects full-scale range of meter M1.

TABLE 3-1 (cont.)

TEST DEMODULATOR
FRONT PANEL CONTROLS

Control Number	Title	Position	Function
DS2	Phase Sense	ILLUMINATED	Indicates that 15 kHz reference is within 90° of pilot signal.
		EXTINGUISHED	Indicates that reference and pilot are more than 90° out of phase.
R1	15 kHz Phase Adjust	TEN (10) TURN POT	Provides fine adjustment of 15 kHz reference signal.
R2	DC Offset	TEN (10) TURN POT	Provides for adjustment of meter zero.
R3	Balance	TEN (10) TURN POT	Provides for adjustment of relative amplitudes of E_{NS} and E_{EW} signals.
M1	Phase Null	---	Indicates relative phase of 15 kHz reference signal.
J1	NS Output	---	NS audio signal output.
J2	EW Output	---	EW audio signal output.
J3	OMNI Output	---	OMNI audio signal output.
J4	EXT. Input Signal	---	DIFAR composite signal input from external equipment.

3.3 OPERATIONAL CALIBRATION:

Because of the extreme precision required in alignment of the reference signal to the 15 kHz pilot component of the input signal and balance of the two directional signal channels (NS and EW), provisions have been made to calibrate the phase metering circuitry and the inter-channel balance through the use of self-generated test signals and front panel controls.

3.3.1 DC OFFSET CALIBRATION:

After the prescribed 30 minute warmup, and as frequently as required thereafter, perform the following:

1. Connect wave analyzer to NS output J1.
2. Tune analyzer to 29 Hz
3. Set Input Switch S2 to METER CAL
4. Manipulate Phase Advance S3 and Phase Adjust R1 for a condition of Phase Sense DS2 ILLUMINATED and minimum 29 Hz signal.
5. Set Meter Sensitivity Switch S5 to X1.
6. Adjust DC Offset Control R2 for zero indication on Phase Null Meter M1.

3.3.2 BALANCE CALIBRATION:

1. Connect AC Ratio Meter to NS and EW outputs at J7 on rear panel.
2. Set Input Switch S2 to BAL
3. Manipulate Phase Advance S3 and Phase Adjust R1 for Phase Sense DS2 ILLUMINATED and zero indication on Phase Null Meter M1.
4. Adjust Balance Control R3 for a ratio of 1.000 on the Multi-Function Meter.

3.4 DEMODULATION OF A DIFAR COMPOSITE SIGNAL:

After calibration, all that is required to demodulate a DIFAR composite signal is to apply the input signal, align the reference signal to the 15 kHz pilot, and make the desired measurements at the appropriate output. This may be accomplished by the following:

1. Apply a DIFAR composite signal to any of the available input connectors (J4 or J7).
2. Select the appropriate input with DIFAR Input Switch S4.
3. Manipulate Phase Advance Switch S3, Phase Adjust Control R1, and Meter Sensitivity Switch S5 for a zero indication on the Phase Null Meter M1 with the Meter Sensitivity Switch in X1 position and the Phase Sense Lamp DS2 ILLUMINATED.
4. Proper signals are now available at J1, J2, J3, and J7.

4.0 THEORY OF OPERATION:

4.1 GENERAL:

A block diagram of the Test Demodulator is shown in Figure 4-1. The drawing number for each of the card schematics is listed below:

Card	Name	Schematic
A1	Demodulator	D16638
A2	Frequency Multipliers	D16428
A3	Input Amplifier and Filters	D16635
A4	Self Test Generator	D16632
A5	Filters	D17319

The overall chassis schematic, showing the interconnect between cards, is given in drawing J16639.

The Test Demodulator is divided into three functional sections (DIFAR mode, balance mode, and meter calibration mode) for convenience in describing its theory of operation.

4.2 DIFAR MODE:

4.2.1 OMNI Output:

The composite signal, from either the CD-3800 System Simulator or an external source, is passed through a buffer amplifier (IC1 on card A3) and applied to the OMNI compensation network (IC6 on card A3). This circuit compensates the OMNI signal to account for the effects of the linear-phase filter upon the directional signals. The OMNI signal is then put through a low-pass filter (Q1-Q4 on A3) and buffer (IC7 on card A3) to extract the the 10 Hz to 2400 Hz baseband. The OMNI OUTPUT signal is available at connector J3 on the front panel, and at connector J7 on the rear panel.

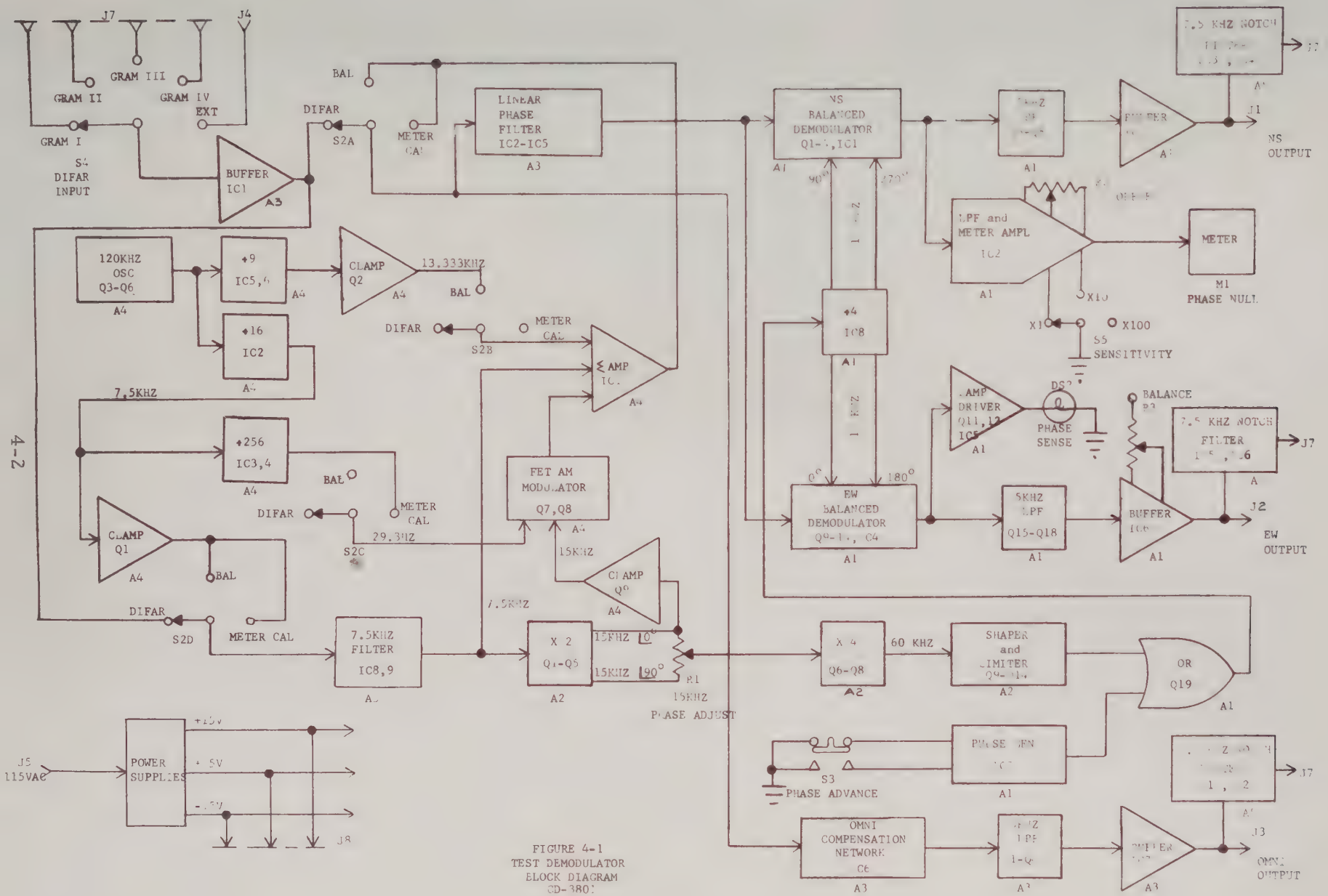

FIGURE 4-1
TEST DEMODULATOR
BLOCK DIAGRAM
CD-3807

Minimum filtering is utilized at this point to insure a stable phase relationship with the NS and EW channel signals. The OMNI Signal, with additional filtering (IC1 and 2 on Card A5) to facilitate broadband amplitude measurements, is available at connector J7 on the rear panel.

4.2.2 NS Output:

The composite input signal is also applied to the linear-phase filter (IC2-IC5 on card A3). This filter passes all signals between 12.6 kHz and 17.4 kHz and rejects all others. The output of the filter is applied to a pair of balanced synchronous demodulators. The output of the NS demodulator (Q1, Q2 and IC1 on card A1) is fed through a low-pass filter (Q5-Q8 on card A1) and a buffer (IC3 on card A1) to give the NS OUTPUT signal. It is available at connector J1 on the front panel and after additional filtering (IC3, IC4 on card A5) at connector J7 on the rear panel.

The reference signal for the demodulator is derived from the 7.5 kHz pilot in the composite signal in the following manner:

The composite signal is applied to a 7.5 kHz filter (IC8, IC9 on card A3).

The filter output is doubled (Q1-Q5 on card A2) to 15 kHz, and applied to phase adjust control R1 directly and in quadrature. The output of R1 is multiplied to 60 kHz (Q6-Q8 on card A2), shaped and limited to 5 volts (Q9-Q13 on card A2), differentiated and clipped to form a narrow trigger (Q14 on card A2), and applied to an OR gate (Q19 on card A1). The other input of the OR gate comes from a pulse generator (IC7 on card A1) which is toggled by PHASE ADVANCE switch S3. Each time the PHASE ADVANCE switch is depressed, an extra pulse is added to the output of the OR gate. This has the effect of advancing the phase of the demodulator reference signal by 90° increments, because the OR gate output is subsequently divided by four (IC8 on card A1) before being applied to the demodulators.

The relative phase shift between the 15 kHz pilot from the composite input signal and the NS 15 kHz reference signal generated in the Test Demodulator is displayed on PHASE NULL meter M1. A low-pass filter and meter amplifier (IC2 on card A1) is connected to the output of the NS balanced demodulator. When the two 15 kHz signals are 90° out of phase the dc output of the demodulator is zero volts, and the meter indicates zero. As the phase relationship of 15 kHz signals deviate from a 90° phase relationship, a dc component is obtained from the NS demodulator, and the meter is deflected accordingly.

4.2.3 EW Output:

The composite signal is applied to a balanced synchronous demodulator (Q9-Q10, IC4 on card A1), low-pass filter (Q15-Q18 on card A1), and buffer (IC6 on card A1) in the same manner as described for the NS channel. The major difference is that the reference signals used in the demodulation process differ by 90° from that used in the NS channel. BALANCE control R3 is connected in the buffer feedback loop to allow the EW output to be adjusted to the same amplitude as the NS output.

A lamp driver (IC5, Q11, Q12 on card A1) and PHASE SENSE indicator DS2 are connected to the output of the EW demodulator. The lamp is illuminated when the 15 kHz pilot from the composite and the EW 15 kHz reference are within approximately 45° of being in phase. From that point on, PHASE NULL meter M1 is used.

4.2.4 FILTERED OMNI, NS, and EW Outputs:

The output signals available at connectors J1, J2, and J3 have had minimum filtering utilized to insure a stable phase interrelationship. Due to the strong high frequency components present in these outputs, they are not suitable for amplitude measurement except with a wave analyzer or tracking filter.

To facilitate amplitude measurements with a broadband instrument, additional filtering is provided for the three signals: OMNI (IC1-IC2 on card A5), EW (IC5-IC6 on card A5), and NS (IC3-IC4 on card A5). The three filters are closely matched in amplitude response from 0 to 2,400 Hz. Each channel provides approximately 60 db attenuation at 7.5 kHz decreasing to 30 db at 15 kHz then increasing at a 12 db/octane rate above 15 kHz. The center frequency of the notch is adjustable by the variable inductors on card A5.

The three filtered outputs are available at connector J7 on the rear panel.

4.3 BALANCE MODE:

When INPUT switch S3 is turned to the BAL position, the DIFAR composite signal is removed from the Test Demodulator.

In its place is a composite signal composed of a 7.5 kHz pilot, a 15 kHz carrier, and a 13.333 kHz signal which simulates a single sideband modulation of the 15 kHz carrier by a 1,667 Hz modulation signal. These signals are obtained by counting down the output of a 120 kHz crystal controlled oscillator (Q3-Q6 on card A4).

The 7.5 kHz signal results from dividing the oscillator by 16 (IC2 on card A4). The 13.333 kHz signal is generated by dividing the oscillator output by a factor of 9 (IC5, IC6 on card A4). The

15 kHz signal is obtained through filtering (IC8, IC9 on card A3) of the clamped 7.5 kHz signal (Q1 on card A4), then frequency multiplying to 15 kHz (Q1-Q5 on card A2), and buffering (Q9 on card A4).

The composite signal is formed by summation (IC1 on card A4) of the three components. From here the composite signal is applied to the linear phase filter and processed in a similar manner as the DIFAR composite signal.

Since the output of a synchronous demodulator is independent of the phase relationship between the carrier and reference signal when processing a single sideband signal, the outputs of the NS and EW channels should be equal amplitudes of the 1,667 Hz demodulation product. The gain of the EW channel is adjustable to obtain the desired balance.

4.4 METER CALIBRATION MODE:

When INPUT switch S3 is turned to the METER CAL position, a composite signal is generated in the following manner: the 7.5 kHz signal is divided by 256 (IC3, IC4 on card A4) to give 29.3 Hz which is applied to the FET modulator (Q7, Q8 on card A4). The 15 kHz signal is modulated by the 29.3 Hz signal to give sidebands at 15,029.3 Hz and 14,970.7 Hz, in addition to the two original signals. The 7.5 kHz signal is added to the modulator output in the summing amplifier (IC1 on card A4). The resultant composite has a frequency reference at 7.5 kHz, a phase reference at 15 kHz, an OMNI target signal at 29.3 Hz, and a directional target. The carrier and the pilot are in phase, because they are identical,

thus defining the target as an EW Cardinal. Under this condition there is no output from the NS demodulator when the 15 kHz reference is in phase with the pilot, and DC OFFSET control (R1) may be adjusted for a zero indication on PHASE NULL meter (M1).

5.0 CALIBRATION:

This section of the manual provides the procedures necessary to calibrate the Test Demodulator panel. The calibration procedures are written in the sequence that the calibration should be performed. These calibration procedures are based on the assumption that the panel has been properly installed and connected.

CAUTION

Deviation from the sequence of the procedures provided could result in erroneous calibration and/or cause a reiteration process.

5.1 CALIBRATION RECURRENCE:

The Test Demodulator panel is designed to operate within the specified tolerances for a period of 336 consecutive hours. At the end of that period, the calibration procedures given in this section shall be performed.

5.2 CALIBRATION ACCURACY:

Tolerance for signals are not specified in the Test Demodulator calibration procedures herein. The tolerances of the support equipment is the only allowable deviation.

5.3 SUPPORT EQUIPMENT:

The following test equipment is necessary to perform calibration on the Test Demodulator panel:

	Type Equipment	Model
a.	Hewlett-Packard Multi-function Meter	3450-001
b.	Hewlett-Packard Counter	5245L
c.	General Radio Frequency Synthesizer	1161

Type Equipment	Model
d. Hewlett-Packard Wave Analyzer	3590A
e. Test Leads	------

5.4 EQUIPMENT WARMUP:

Power should be applied to the Test Demodulator panel and support test equipment at least 30 minutes prior to starting the calibration. Set the Test Demodulator panel controls as follows prior to applying power to the panel.

Controls	Position
a. Input (S2)	DIFAR
b. Phase Advance (S3)	-
c. DIFAR Input (S4)	EXT
d. Meter Sensitivity (S5)	X100

5.5 PRINTED CIRCUIT CARDS:

There are five (5) printed circuit cards located in the Test Demodulator panel. Their locations and names are as follows:

Panel Location	Name	Part No.	Keying
A1	Demodulator	16636-1	J-K
A2	Frequency Multiplier	16426-1	E-F
A3	Input Amplifiers and Filters	16633-1	H-J
A4	Self Test Generator	16429-1	F-H
A5	Filters	17317-1	B-C & L-M

5.6 CALIBRATION PROCEDURES:

5.6.1 Power Supplies:

Step 1: On the Test Demodulator panel, set the AC POWER switch (S1) to the OFF position.

Step 2: Extend the Test Demodulator panel on slides by loosening the four thumbscrews and pulling on the front panel handle.

Step 3: On the rear of the Test Demodulator panel, remove dc output cable connector from receptacle J8.

Step 4: Remove printed wire assemblies A1 through A5.

Step 5: Use the test leads to connect the Hewlett-Packard Multi-function Meter (Model 3450A) to (+) 15VDC (PS1) power supply output terminals (located at bottom of power supply) as follows:

a. Connect the negative (-) test lead from the Multi-function meter to terminal #4 on PS1.

b. Connect the positive (+) test lead to terminal #1 on PS1.

Step 6: Perform the necessary adjustments on the Hewlett-Packard Multi-function Meter to read (+) DC volts.

Step 7: On the Test Demodulator panel, set the AC POWER switch (S1) to the ON position.

Step 8: On (+) 15VDC Power Supply (PS1), turn the voltage adjust screw (located on top of PS1) CW until Multi-function Meter indicates (+)16.5 VDC.

Step 9: On (+)15VDC Power Supply (PS1), turn the over-voltage protection adjustment screw (accessible through the rear of the Test Demodulator panel) until the overvoltage protector actuates.

NOTE: Each time an overvoltage protector is actuated, it may be reset by cycling AC POWER switch (S1) OFF, then back ON, after turning the power supply voltage adjust screw CCW.

Step 10: On (+)15VDC Power Supply (PS1), turn the voltage adjust screw (CCW) until the Multi-function Meter reads (+)15VDC.

Step 11: On the Test Demodulator panel, set the AC POWER switch (S1) to the OFF position.

Step 12: Remove the Multi-function Meter test leads from PS1 output terminals and connect the test leads to (-) 15VDC power supply (PS2) output terminals as follows:

a. Connect the negative (-) test lead from the Multi-function Meter to terminal #4 on PS2.

b. Connect the positive (+) test lead to terminal #1.

Step 13: On the Test Demodulator panel, set the AC POWER switch (S1) to the ON position.

Step 14: On (-)15VDC Power Supply (PS2), turn the voltage adjust screw CW until the Multi-function Meter indicates (-)16.5 VDC.

Step 15: On (-)15VDC Power Supply (PS2), turn the over-voltage protection adjustment screw until the overvoltage protector actuates.

Step 16: On (-)15VDC Power Supply (PS2), turn the voltage adjust screw (CCW) until the Multi-function Meter indicates (-)15VDC.

Step 17: On the Test Demodulator panel, set the AC POWER switch (S1) to the OFF position.

Step 18: Remove the Multi-function Meter test leads from PS2 output terminals and connect the test leads to (+)5VDC Power Supply (PS3) output terminals as follows:

a. Connect the negative (-) test lead from the Multi-function Meter to terminal #4 on PS3.

b. Connect the positive (+) test lead to terminal #1.

Step 19: On the Test Demodulator panel, set the AC POWER switch (S1) to the ON position.

Step 20: On (+)5VDC Power Supply (PS3), turn the voltage adjust screw CW until Multi-function Meter indicates (+)5.5VDC.

Step 21: On (+)5V Power Supply (PS3), turn the overvoltage protection adjustment screw until the overvoltage protector actuates.

Step 22: On (+)5VDC Power Supply (PS3), turn the voltage adjust screw (CCW) until the Multi-function Meter reads (+)5VDC.

Step 23: On the Test Demodulator panel, set the AC POWER switch (S1) to the OFF position.

Step 24: On the Multi-function Meter, set the POWER switch to the OFF position and remove the meter test leads from PS3 output terminals.

Step 25: On the Test Demodulator panel, insert printed circuit cards A1 through A5 in their respective connectors in the card nest.

Step 26: On the rear of the Test Demodulator panel, connect the dc output cable connector to receptacle J8.

5.6.2 Input Amplifiers and Filters Calibration:

CAUTION: Potentiometers R9, R11, R15, R17, R23, R24, R32, and R34 on card A3 are used for initial factory alignment and must not be disturbed during routine calibration. Refer to the Appendix for alignment procedure in the event of board malfunction and repair.

Step 1: Connect the Frequency Synthesizer to the EXT INPUT SIGNAL receptacle (J4).

Step 2: Set the Frequency Synthesizer output to 1.6 V rms ± 16 mV rms at 7.5 kHz ± 1 Hz, AC Output Coupling.

Step 3: Connect the Wave Analyzer to test points E9 (high) and E5 (low) on card A3.

Step 4: Tune the Wave Analyzer to 7.5 kHz (100 Hz Bandwidth).

Step 5: On the Test Demodulator panel, set the controls as follows prior to applying power:

Controls	Position
a. Input (S2)	DIFAR
b. Phase Advance (S3)	-
c. DIFAR Input (S4)	EXT
d. Meter Sensitivity	X100

Step 6: On the Test Demodulator panel, set the AC POWER switch (S1) to the ON position.

Step 7: Using a plastic tuning tool, adjust coils L1 and L2 on card A3 for maximum 7.5 kHz amplitude as indicated on the Wave Analyzer.

Step 8: Record the 7.5 kHz amplitude: _____ Vrms.

NOTE: This voltage level will be used in Section 5.6.4 to align the self test generator.

5.6.3 Frequency Multiplier Calibration:

Step 1: Repeat Steps 1, 2, and 4 through 6 of Section 5.6.2.

Step 2: Connect the Wave Analyzer to test points E1 (high) and E3 (low) on card A2.

Step 3: Tune the Wave Analyzer to 15 kHz (100 Hz bandwidth).

Step 4: Adjust coil L1 on card A2 for maximum 15 kHz amplitude, as indicated on the Wave Analyzer.

Step 5: Adjust potentiometer R17 on card A2 for a 15 kHz level of 850 mVrms ± 5 mVrms, as indicated on Wave Analyzer.

Step 6: Connect the Wave Analyzer to test point E2 (high) on card A2.

Step 7: Tune the Wave Analyzer to 60 kHz (1,000 Hz bandwidth).

Step 8: Adjust coils L2, L3, and L4 on card A2 for maximum 60 kHz amplitude, as indicated on the Wave Analyzer.

Step 9: Connect the Wave Analyzer to test point E4 (high) on card A2.

Step 10: Adjust coil L5 on card A2 for maximum 60 kHz amplitude, as indicated on the Wave Analyzer.

5.6.4 Self Test Generator Calibration:

Step 1: On the Test Demodulator panel, set the controls as follows:

Control	Position
a. Input (S2)	METER CAL
b. Phase Advance (S3)	-
c. DIFAR Input (S4)	-
d. Meter Sensitivity	X100

Step 2: Connect the counter to test points E1 (high) and E5 (low) on card A4.

Step 3: Verify that the counter indicates 120 kHz ± 50 Hz.

Step 4: Remove the Counter test leads from card A4.

Step 5: Connect the Wave Analyzer to test points E9 (high) and E5 (low) on card A3.

Step 6: Tune the Wave Analyzer to 7.5 kHz.

Step 7: Adjust potentiometer R14 on card A4 for the same 7.5 kHz amplitude as that recorded in paragraph 5.6.2, Step 8.

Step 8: Connect the Wave Analyzer to test point E1 (high) of card A3.

Step 9: Adjust potentiometer R23 on card A4 for a 7.5 kHz signal amplitude of 220 mVrms $\pm$ 5 mVrms.

Step 10: Tune the Wave Analyzer to 15 kHz.

Step 11: Adjust potentiometer R37 on card A4 for a 15 kHz signal amplitude of 220 mVrms $\pm$ 5 mVrms.

Step 12: Tune the Wave Analyzer to 13.333 kHz.

Step 13: On the Test Demodulator panel, set the INPUT switch (S2) to the BAL position.

Step 14: Adjust potentiometer R18 on card A4 for a 13.333 kHz amplitude of 75 mVrms ± 5 mVrms.

5.6.5 Filter Calibration:

CAUTION: Potentiometers R9, R14, R19, and R24 are used for initial factory alignment and must not be disturbed during routine calibration. Refer to the APPENDIX for alignment procedures in the event of board malfunction and repair.

Step 1: Remove boards A1 and A3.

Step 2: Connect Frequency Synthesizer to J3.

Step 3: Set Synthesizer to 7,500 Hz.

Step 4: Connect Wave Analyzer to A5E5 LO and A5E8 HI.

Step 5: Tune Analyzer to 7,500 Hz (100 Hz Bandwidth)

Step 6: Adjust Coils L1 and L2 for minimum 7,500 Hz output.

Step 7: Connect Frequency Synthesizer to J1.

Step 8: Connect Wave Analyzer to A5E6 HI.

Step 9: Adjust Coils L3 and L4 for minimum 7,500 Hz output.

Step 10: Connect Frequency Synthesizer to J2.

Step 11: Connect Wave Analyzer to A5E7 HI.

Step 12: Adjust Coils L5 and L6 for minimum 7,500 Hz output.

5.6.6 Demodulator Calibration:

CAUTION: Potentiometers R60 and R62 used for initial factory alignment and must not be disturbed during routine calibration. Refer to the APPENDIX for alignment procedure in the event of board malfunction and repair.

Step 1: On the Test Demodulator panel, set the controls as follows:

	Control	Position
a.	Input (S2)	METER CAL
b.	Phase Advance (S3)	-
c.	DIFAR Input (S4)	-
d.	Meter Sensitivity (S5)	X100
e.	15 kHz Phase Adjust (R1)	Midrange
f.	DC Offset (R2)	Midrange
g.	Balance (R3)	Midrange

Step 2: Connect the Wave Analyzer to the NS OUTPUT at connector J7.

Step 3: Tune the Wave Analyzer to 29.3 Hz. (10 Hz Bandwidth).

Step 4: Depress and release the PHASE ADVANCE switch (S3) until the PHASE SENSE lamp (DS2) illuminates.

Step 5: Adjust the 15kHz PHASE ADJUST control (R1) for minimum 29.3 Hz amplitude, as indicated on the Wave Analyzer.

Step 6: Adjust the DC OFFSET control (R2) for zero indication on the PHASE NULL Meter (M1).

Step 7: Turn the METER SENSITIVITY switch (S5) to the X10 position and repeat Step 6.

Step 8: Turn the METER SENSITIVITY switch (S5) to the X1 position and repeat Step 6.

Step 9: Connect the Wave Analyzer to the EW OUTPUT at Connector J7.

Step 10: Record the 29.3 kHz amplitude: _____.

Step 11: Multiply level recorded in Step 10 by 0.0524: _____.

Step 12: Connect the Wave Analyzer to the NS OUTPUT jack (J1).

Step 13: Set the METER SENSITIVITY switch (S5) to the X10 position.

Step 14: Adjust the 15KHZ PHASE ADJUST control (R1) for a 29.3 Hz amplitude, as indicated on the Wave Analyzer, equal to that calculated in Step 11.

Step 15: Adjust potentiometer R27 on card A1 for an indication of +3 degrees on the PHASE NULL meter (M1).

Step 16: Turn the INPUT switch (S2) to the BAL position.

Step 17: Connect X Input of Multi-function Meter to NS Output at Connector J7.

Step 18: Connect Y Input of Multi-function Meter to EW Output at Connector J7.

Step 19: Program Multi-function Meter to read AC-Ratio.

Step 20: Adjust potentiometer R74 on card A1 for a ratio of 1.000.

6.0 MAINTENANCE INSTRUCTIONS:

All repair and preventive maintenance efforts associated with the Test Demodulator must be performed by trained technicians. The technician should follow a logical sequence of steps to complete the repair and preventive maintenance effort in the shortest possible time.

6.1 ROUTINE MAINTENANCE:

Periodically and following relocation of the Test Demodulator, all subassemblies and wiring should be checked for damage.

A regular inventory survey should be conducted to maintain a complete supply of spare parts prior to supporting a test effort.

6.2 PREVENTIVE MAINTENANCE:

To assist in preventing support shut down or erroneous operation, it is recommended that a calibration test be performed on the Test Demodulator as required in Paragraph 5.1.

6.3 TROUBLESHOOTING:

As it is expected that a competent technician will perform any troubleshooting operations on the test demodulator, no step-by-step procedure is provided. The following signal voltage tables and descriptions of the less obvious malfunctions should suffice for all normal troubleshooting.

6.3.1 Small Bearing Errors:

Small bearing errors may be caused by: improper alignment of the incoming pilot phase, improper alignment of DC offset in the phase null meter circuitry, excessive non-linearity of phase response in the linear phase filter, excessive unbalance in the amplitude response for the two sidebands through the linear phase filter, or an unbalance in voltage gain through the two directional channels.

Condition 1. - Excessive bearing error is independent of target frequency and nominal target bearing. The probable cause is improper phase relationship between the reference signals and the directional carriers, i.e., either misalignment of input 15 kHz pilot phase or maladjustment of the phase null metering circuitry.

Condition 2. - Excessive bearing error is a function of bearing angle but not target frequency, with the error maximum at intercardinal bearings and minimum at cardinal bearings. The probable cause is an unbalance in gain through the two directional channels.

Condition 3. - Excessive bearing error is a function of target frequency but not of bearing angle and is maximum at the higher target frequencies. The probable cause is excessive nonlinearity of phase response through the linear phase filter.

Condition 4. - Excessive bearing error is a function of both target frequency and bearing angle with maximum error at high frequency cardinal bearings. The probable cause is excessive unbalance in the amplitude response for the two sidebands through the linear phase filter. This cause may be confirmed by observing the relative phase between the two directional channel signals. The proper phase relationship is 0° or 180°. If the error is due to sideband amplitude unbalance, the phase relationship will approach 90°.

Condition 5. - Excessive bearing error is a function of both frequency and bearing angle with an excessive error at both high frequency cardinal and intercardinal bearings. The probable cause is a combination of excessive nonlinearity of phase response

and unbalance in sideband amplitude response through the linear phase filter.

6.3.2 Gross Bearing Errors and Total Malfunction:

In the event of large bearing errors or total test demodulator malfunction the following test conditions and signal voltage measurements are provided as an aid to isolate the malfunction.

Condition 1. - OMNI Channel Test: Signal applied to J4 - 1 Vrms, 1,000 Hz. (Measure with RMS Voltmeter.)

A3E1 0.12 Vrms
A3E3 0.12 Vrms
A3E7 3.7 Vrms
A5E4 3.7 Vrms
A5E8 3.7 Vrms
J4 3.7 Vrms
J7 3.7 Vrms

Condition 2. - Reference Signal Generation: Signal applied to J4 - 1.6 Vrms, 7,500 Hz. (Measure with Wave Analyzer.)

A3E1	0.23 Vrms	7,500 Hz
A3E8	0.97 Vrms	7,500 Hz
A3E9	2.35 Vrms	7,500 Hz
A2E1	~~0.85~~ 2.70 Vrms	15 kHz
A2E2	0.~~23~~ .73 Vrms	60 kHz
A2E4	0.60 Vrms	60 kHz
A1E1	0.11 Vrms	7,500 Hz
A1E2	0.11 Vrms	7,500 Hz

Condition 3. - Directional Channels Test: Input Switch S2 to BAL. (Measure with Wave Analyzer.)

A3E1 0.23 Vrms 7.5 kHz

	750 mVrms	13.333 kHz
	0.22 Vrms	15 kHz
A3E2	0.26 Vrms	7.5 kHz
	0.11 Vrms	13.333 kHz
	0.33 Vrms	15 kHz
A3E4	0.29 Vrms	7.5 kHz
	0.15 Vrms	13.333 kHz
	0.49 Vrms	15 kHz
A3E6	0.23 Vrms	7.5 kHz
	0.24 Vrms	13.333 kHz
	0.71 Vrms	15 kHz
A1E1	0.11 Vrms	7.5 kHz
	0.5 mVrms	13.333 kHz
	0.97 Vrms	1.667 kHz
A1E2	0.11 Vrms	7.5 kHz
	0.5 mVrms	13.333 kHz
	0.97 Vrms	1.667 kHz
A5E2	0.98 Vrms	1.667 kHz
A5E6	0.99 Vrms	1.667 kHz
A5E3	0.98 Vrms	1.667 kHz
A5E7	0.99 Vrms	1.667 kHz
J1	0.97 Vrms	1.667 kHz
J2	0.97 Vrms	1.667 kHz
J7(NS)	0.99 Vrms	1.667 kHz
J7(EW)	0.99 Vrms	1.667 kHz

APPENDIX A. LINEAR PHASE FILTER CALIBRATION (Card A3)

The Linear Phase Filter has been so designed as to preclude periodic calibration; however, if any of the following components are replaced or change in value due to aging, a calibration must be preformed. R9-R12, R15-R18, R21-R24, C3-C5, C7-C9, and C11-C12.

CAUTION: The soldering of component leads creates a thermal stress and a small shift in component value. This stress will relieve with age, causing a change in the calibration of the filter. USE HEAT SINK ON COMPONENT LEADS when performing soldering operations. Thermal cycling of the printed circuit assembly will accelerate stress relief; therefore, it is advisable to cycle 0° to 70°C 15 minutes at each limit for three cycles before calibrating the filter.

Improper calibration of the linear phase filter is manifested by excessive bearing errors. Lack of phase linearity will be observed as a frequency dependent bearing error which is independent of the absolute bearing angle. Lack of amplitude symmetry will be observed as frequency dependent errors which are more pronounced at the cardinal bearings and minimum at intercardinal bearing angles.

CAPACITOR SELECTION:

Using an impedance bridge, ESI Model 250DA or equivalent, measure the values of C3, C5, C7, and C9. Select capacitors for C4 and C8 to achieve:

$$\frac{C4 + C5}{C3} = 8.140 \pm 0.017 \quad \text{and}$$

$$\frac{C8 + C9}{C7} = 8.140 \pm 0.017 .$$

LOW PASS POTENTIOMETER ADJUSTMENT:

Using the impedance bridge, adjust R9, R11, R15, and R17 to achieve the following:

$$\frac{R9 + R10}{2,870} = \frac{1,000}{C3} \pm 0.001$$

$$\frac{R11 + R12}{2,940} = \frac{1,000}{C3} \pm 0.001$$

$$\frac{R15 + R16}{2,870} = \frac{1,000}{C7} \pm 0.001$$

$$\frac{R17 + R18}{2,940} = \frac{1,000}{C7} \pm 0.001$$

HIGH PASS POTENTIOMETER ADJUSTMENT:

1. Adjust R23 and R24 full CCW.
2. Insert board into test demodulator.
3. Connect frequency synthesizer to EXT input jack J4.
4. Connect ratio meter X input to A3E5 LO and A3E1 HI; and Y input to A3E5 LO and A3E6 HI.
5. Connect North Atlantic Phase Meter signal and reference in parallel with X and Y inputs of ratio meter.
6. Adjust R23 and R24 until the following criteria are met:

$$\text{Voltage ratio } \frac{E6}{E1} \text{ at } 17.3 \text{ kHz} = \frac{E6}{E1} \text{ at } 12.7 \text{ kHz}$$

and

$$\phi \ 12.7 \text{ kHz} - \phi \ 15.0 \text{ kHz} = \phi \ 15.0 \text{ kHz} - \phi \ 17.3 \text{ kHz}.$$

7. Remove test equipment.
8. Connect to the test demodulator input a composite signal which has an adjustable bearing angle and target frequency. (A CD-3800 System Simulator coupled with a CD-3802 Variable Bearing Generator is a suitable source.)

9. Make ~~final~~ adjustment of R23 and R24 with a bearing angle of ~~90°~~ 270° applied adjusting the potentiometers for maximum ratio E_{EW}/E_{NS} with a target frequency of 2,300 Hz and minimum change in indicated bearing as the target frequency is changed from 200 Hz to 2,300 Hz.

10. Remove composite signal and set up to measure phase delay of the filter as in Steps 3-5.

11. Measure and compute:

$$\frac{\phi\ 12.7\ \text{kHz} - \phi\ 17.3\ \text{kHz}}{2} = \underline{\qquad\qquad}$$

(Nominal computed value is 48.5°.)

NOTE: Test frequencies used in this procedure are ± 2 HZ.

APPENDIX B. DIRECTIONAL OUTPUT FILTER CALIBRATION (Card A1)

The output filters provide suppression of the high frequency demodulation products while maintaining phase integrity between the directional and OMNI channel signals. Routine calibration is not required; however, if components are replaced or change in value due to aging, in any of the three signal channels, a calibration must be performed.

Improper calibration is manifested by lack of phase integrity between signal channels.

CALIBRATION:

1. Remove Card A3.
2. Connect the frequency synthesizer ~~to~~ XA1-R, S, or T LO and XA1-1 HI.
3. Set synthesizer to 2,300 Hz, 0.2 vrms.
4. Connect North Atlantic Phase Meter to A1E3 LO, A1E1 Ref HI, and A2E2 Sig HI.
5. Rotate R60 and R62 full CCW.
6. Adjust R60 and R62 for a phase difference of 0°, synchronizing their rotation by alternating one-quarter turn each at a time.
7. Connect phase meter Ref input to synthesizer.
8. Measure and record phase delay - 180°: _____.

NOTE: Some phase meters, such as the North Atlantic 301A, measure signal lead with respect to the reference. To obtain phase delay or lag, subtract lead angle from 360°.

APPENDIX C. OMNI COMPENSATION NETWORK CALIBRATION (Card A3)

This network which is a two pole, active, linear phase filter, functions to compensate the OMNI channel signal for the effects on the directional channel signals by the linear phase filter, thus maintaining phase integrity between the OMNI and directional signals. It has been so designed as to preclude periodic calibration. However, if the linear phase filter is replaced, or if any of the components (R32, R33, R34, R35, C15, C16, or C17) are replaced or change in value because of aging, a calibration must be performed.

Improper calibration of the OMNI compensation network is manifested by an improper phase relationship between the directional and OMNI channel signals. The phase error between channels will increase with the target frequency.

CAPACITOR SELECTION:

Using an impedance bridge, ESI Model 250DA or equivalent, measure the values of C16 and C17. Select a capacitor for C15 to achieve:

$$\frac{C17}{C15 + C16} = 1.394 \pm 0.010.$$

POTENTIOMETER ADJUSTMENT:

1. Adjust R32 and R34 full CCW.
2. Insert board into test demodulator.
3. Connect frequency synthesizer to J4.
4. Connect North Atlantic Phase Meter to A3E5 LO, A3E1 Ref HI, and A3E7 Sig HI.

5. Set synthesizer to 2,300 Hz., 0.2 vrms.

6. Adjust R32 and R34, rotating each one-quarter turn at a time. Obtain a total phase ~~delay through~~ the OMNI channel equal to the sum of the average delay through the linear phase filter (computed in Appendix A) and the delay through the NS channel filter (measured in Appendix B). The nominal value of the total phase delay is 127°.

NOTE: Some phase meters, such as the North Atlantic 301A measure signal lead with respect to the reference. To obtain phase delay or lag, subtract lead angle from 360°.

APPENDIX D. FILTER BOARD CALIBRATION (Card A5)

The filter board provides additional filtering for the three signal channels to facilitate broadband amplitude measurements of the three output signals. In order to maintain bearing accuracy of the test demodulator when measuring the filtered outputs, the frequency response of the two directional channels must match within 0.9965 to 1.0035. This allowable error represents a maximum bearing error attributable to filter mismatch of 0.05°. The error will be maximum at intercardinal bearings, decreasing to zero at cardinal bearings.

CAPACITOR SELECTION:

Using an impedance bridge, ESI Model 250DA or equivalent, measure the values of C2, C4, C12, C14, C22, C24, C7, C9, C17, C19, C27, and C29. Select C1, C3, C11, C13, C21, C23, C6, C8, C16, C18, C26, and C28 so that:

$$C1 + C2 = 9,800 \text{ to } 10,500 \text{ pF and}$$

$$C1 + C2 = C11 + C12 = C21 + C22 \text{ within } \pm 10 \text{ pF.}$$

$$C6 + C7 = 9,800 \text{ to } 10,500 \text{ pF and}$$

$$C6 + C7 = C16 + C17 = C26 + C27 \text{ within } \pm 10 \text{ pF.}$$

$$C3 + C4 = 4,500 \text{ to } 4,700 \text{ pF and}$$

$$C3 + C4 = C13 + C14 = C23 + C24 \text{ within } \pm 5 \text{ pF.}$$

$$C8 + C9 = 4,500 \text{ to } 4,700 \text{ pF and}$$

$$C8 + C9 = C18 + C19 = C28 + C29 \text{ within } \pm 5 \text{ pF.}$$

ALIGNMENT:

1. Perform Filter Calibration (Paragraph 5.6.5).
2. Rotate all potentiometers full CCW.
3. Connect Ratio Meter to A5E5 LO, A5E4-X HI, and A5E2-Y HI.
4. Set synthesizer to 3,500 Hz.
5. Adjust R9 for ratio of 1.000.
6. Set synthesizer to 200 Hz.
7. Measure and record ratio: _____.
8. Set synthesizer to 2,200 Hz.
9. Adjust R9 for same ratio measured in Step 7.
10. Connect Ratio Meter to A5E8-X HI and A5E6-Y HI.
11. Repeat Steps 4-9, substituting R14 for R9: _____.
12. Connect Ratio Meter to A5E2-X HI and A5E3-Y HI.
13. Repeat Steps 4-9, substituting R19 for R9: _____.
14. Connect Ratio Meter to A5E6-X HI and A5E7-Y HI.
15. Repeat Steps 4-9, substituting R24 for R9: _____.
16. Measure and record ratio at specified frequencies (see Table D-1).
17. Adjust potentiometers R19 and R24 as required to obtain a constant ratio ± 0.003.

TABLE D-1. DIRECTIONAL CHANNEL FILTERS
FREQUENCY RESPONSE MEASUREMENT

Frequency (Hz)	NS/EW Ratio (at test points E6/E7) Trial #1	Trial #2	Trial #3	Trial #4
200				
500				
700				
1,000				
1,500				
1,800				
2,000				
2,200				
2,400				